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Design Review of the Controller-Pilot Data Link Communications – Build I (CPDLC-1) Functionality and Computer-Human Interface for the Display System Replacement

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16. Abstract

This report documents the results of a controller design review of the proposed functionality and computer-human interface for Controller-Pilot Data Link Communications Build 1 (CPDLC-I) planned for implementation on the Display System Replacement (DSR).

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EXECUTIVE SUMMARY

This report documents the results of a controller design review of the proposed functionality and computer-human interface for Controller-Pilot Data Link Communications Build I (CPDLC-I) planned for implementation on the Display System Replacement (DSR).

Thirteen Air Traffic Control Specialists and Supervisors participated in the review. Organizations represented by the participants included the Air Traffic Data Link Validation Team (ATDLVT), the DSR Design Team, the Minneapolis Air Route Traffic Control Center (ARTCC), and the National Air Traffic Controllers Association (NATCA). As preparation for the design review, the controllers received 2 days of classroom training sessions and hands-on air traffic control (ATC) simulation experiences designed to familiarize them with CPDLC-I, the DSR workstation, and the proposed CPDLC-I controller interface for DSR. Each controller then completed a structured, independent review of the CPDLC-I functionality and interface design. Finally, the controllers participated in a group debriefing.

The design review exercise produced data on controller preferences for assignment of DSR Category Keys to CPDLC-I functions and generated findings which indicate that modifications are needed to the proposed CPDLC-I display, control and service designs. Key results included: (1) a requirement for three Category Keys to support single keystroke access to both the Transfer of Communication (TOC) and Predefined Message services, and to adjust Data Link Settings, (2) a need to modify the Initial Contact (IC) service design to permit the aircraft altitude report to be compared to an adapted altitude as well as an assigned or interim altitude previously entered by the controller, and (3) a requirement to add the "no response" message type to the proposed set of pilot response options. The participants also generated 12 additional recommendations for modifications to the computer-human interface to enhance controller performance, reduce errors, and increase the acceptability of the system.

1.   INTRODUCTION.

1.1   BACKGROUND.

The Federal Aviation Administration (FAA) intends to field an International Civil Aviation Organization (ICAO)-compliant, En Route Controller-Pilot Data Link Communications (CPDLC) capability in the National Airspace System (NAS) by 2003. In its final form, CPDLC will provide controllers with the ability to uplink a variety of clearance and advisory messages to equipped aircraft, and aircrews will be able to downlink reports and Air Traffic Control (ATC) requests.

As a step toward achieving this goal, the FAA is planning a 12- to 18-month field test of CPDLC to validate some of its potential benefits, serve as a proof of concept, and generate data to assist in the development of the end-state system. The field test will be conducted at the Minneapolis Air Route Traffic Control Center (ARTCC) and will provide a subset of the end-state en route CPDLC messages known as CPDLC Build I (CPDLC-I).

CPDLC-I will offer a capability for controllers to send the transfer of communication (TOC) message using Data Link, and for pilots to respond to the TOC by accepting or rejecting the message. As part of the acceptance reply, pilots may downlink an initial contact (IC) message containing the aircraft's assigned altitude as they enter a new en route sector. Upon receipt of the IC, the ATC system will automatically verify the altitude and alert the new controller if it fails to match the assigned altitude (or interim altitude) stored in the NAS database. CPDLC-I also will provide a capability to send altimeter setting messages (ASM) to aircraft and to uplink predefined messages (PDM) containing nonsafety critical information.

The CPDLC-I messages will be transmitted to properly equipped aircraft via an existing very high frequency (VHF) Data Link network supplied by a commercial air-ground communications service provider. Associated Data Link aircrew interfaces and avionics currently installed on the flight decks of many commercial transport aircraft will be used to support the airborne portion of the system. On the ground, CPDLC-I will be supported by the Host Computer System and the Data Link Applications Processor. CPDLC-I functionality will be integrated with the display and input devices of the Display System Replacement (DSR) controller workstation that will be operational at the Minneapolis ARTCC prior to the field test.

The Operational Test (OT) of CPDLC-I will be conducted at the FAA William J. Hughes Technical Center in advance of the field implementation. As a part of the OT effort, Minneapolis ARTCC

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in high fidelity ATC simulation scenarios to evaluate the operational effectiveness, suitability, and acceptability of CPDLC-I.

1.2   CPDLC-I IMPLEMENTATION ISSUES.

The FAA Technical Center has conducted high fidelity simulation research on ATC Data Link communications for the past 10 years. This research has produced an en route controller interface for CPDLC and related procedures that support effective controller performance and minimize controller workload. In addition, these studies have shown that availability of the full en route CPDLC message set will significantly reduce voice radio frequency congestion, and that CPDLC can increase controller effectiveness and produce tangible benefits to NAS users.

Differences between the CPDLC system and message set used in the studies cited above and the limited message set provided by CPDLC-I suggest that only a small subset of the conclusions and benefits from the simulation research may be applicable to CPDLC-I. Efforts to determine the potential impact of some of these differences will have to await the full-scale simulation capabilities and information that will be available during the OT exercise. For example, while the performance characteristics of the Aeronautical Telecommunications Network (ATN) were assumed during original CPDLC development, CPDLC-I will use the commercial provider's VHF Data Link network. The speed and reliability of this network for delivering ATC messages will be determined during the technical portion of OT, and these performance characteristics will be replicated during controller-in-the-loop simulations designed to assess operational suitability and effectiveness.

Other differences between the CPDLC system tested in simulation research and CPDLC-I can be initially addressed prior to the OT effort. The computer-human interface (CHI) for CPDLC was developed and tested on the Plan View Display (PVD) that is currently operational in ARTCCs. CPDLC-I will use the new DSR workstation. Physical display and control differences between the PVD and DSR systems, as well as display software differences may require that the CHI for CPDLC-I be somewhat different than the one used during previous CPDLC simulations. In addition, the proposed functionality for the services included in CPDLC-I differs from that developed and tested in earlier research. For these reasons, user input is needed to ensure that the transition of Data Link messaging capabilities to the DSR platform maintains the advantages of the system developed on the PVD platform during CPDLC simulation activities.

2. OBJECTIVE.

The objective of the design review exercise documented in this report was to identify functional and CHI control and display options that are operationally suitable and acceptable to controllers for implementing CPDLC-I capabilities on the DSR. Hands-on simulation exercises, visual aids, and system design descriptions were used to provide participating controllers with an understanding of CPDLC-I functionality and the proposed CPDLC-I CHI for DSR. The structured expert inputs of these controllers were used as a basis for recommending preferred design options and any modifications to the CPDLC-I that may be needed prior to OT.

3. TEST CONDUCT.

3.1 TEST PARTICIPANTS.

The participants in this study were 13 en route air traffic control specialists and supervisors. Five of the controllers were individuals who possess subject matter expertise on ATC Data Link communications. Four of these were the en route members of the Air Traffic Data Link Validation Team (ATDLVT). The ATDLVT was established to provide user input during the development of the full CPDLC message set and PVD CHI design. Each of the controllers assigned to the team participated extensively in the design process and has many hours of experience in using CPDLC during high fidelity simulation studies. The fifth controller with Data Link expertise was the National Air Traffic Controller Association (NATCA) representative for Data Link.

Four additional controllers were drawn from an air traffic team that is participating in the DSR development process. One of the controllers was the NATCA representative to the team. These controllers are familiar with the DSR CHI and associated input and display conventions.

Three controllers were from the Minneapolis ARTCC where the operational implementation of CPDLC-I will occur for the field test. The final participant was the NATCA representative who will participate in the development and evaluation of CPDLC-I training.

Informed consent to participate in the exercise was obtained from each participant upon arrival at the FAA Technical Center. The consent form is contained in appendix A of this document.

3.2   TEST FACILITIES.

The exercise was conducted at the FAA Technical Center. Conference facilities were used for test participant briefings, presentations on CHI design options, and debriefing discussions. FAA simulation laboratories located at the Technical Center were used for demonstrations, hands-on exercises, and CHI design review activities.

The NAS en route laboratory houses the Host Computer System and PVD controller workstations that are used to display radar and system data and to enter system inputs. The laboratory appearance is identical to an operational en route control area and includes a full voice communications system. The participants in this study controlled traffic in the NAS laboratory in order to gain/refresh their knowledge of the CHI originally developed for CPDLC. Low to moderate traffic ATC scenarios were presented to the controllers under the Host dynamic simulation (DYSIM) training mode. The DYSIM mode permits a pseudopilot stationed at a PVD to enter inputs that control displayed aircraft in response to controller communications. A Sun Workstation emulated the future ground Data Link processor and supported all digital communications between the participating controllers and pseudopilots. Software originally written to develop and test the full CPDLC message set on the Host/PVD system was used to provide Data Link functionality during the CHI familiarization activity.

The DSR laboratory was for hands-on examination and manipulation of the DSR CHI. No CPDLC-I functionality was implemented on the DSR for this study. However, the DSR displays and input devices were fully functional and the system permitted interactive simulation using all other en route NAS commands.

3.3   TEST PROCEDURES.

The exercise was conducted over a period of 3 days. Upon arrival at the test site, the participants received an overview briefing describing the objective of the study, the activities that would be conducted, and their responsibilities in the review of the CPDLC-I CHI for DSR. Following this overview, the controllers were asked to read and sign the informed consent document required for participation in the study (see appendix A).

3.3.1 PVD CPDLC CHI Familiarization.

Activities began with a 1-hour classroom training session to familiarize the controllers with Data Link CHI originally developed for the Host/PVD system. The purpose of this training was to provide the controllers with

knowledge of the PVD inputs and displays that would act as a baseline for evaluating the proposed CPDLC-I service designs for the DSR. The training covered all CPDLC messages, but emphasized those functions included in CPDLC-I.

The classroom session was followed by two, 2-hour practice periods in the Host/PVD NAS laboratory. A one-half hour discussion session was conducted between the practice periods to answer any open questions about the CPDLC CHI and the rationale that guided its design.

Controllers were assigned to the radar and data positions for the practice exercise. ATC scenarios derived from Atlanta ARTCC airspace were used to permit the controllers to interact with the simulated aircraft using Data Link. Facilitators were available to assist the controllers with the CPDLC message inputs and acquaint them with the airspace and traffic flow in the simulated sectors. The controllers were given a checklist of CPDLC tasks to perform while controlling traffic in the scenario. These tasks required the controllers to exercise all of the Data Link settings controls, send the TOC message using both the manual and automatic modes, observe the Full Data Block (FDB) displays of transaction status and equipage/eligibility, and experience failure displays including "time-out" and IC altitude mismatches. Each pair of controllers alternated between the positions at their sector in order to provide them with experience in the radar and data CPDLC inputs.

3.3.2 DSR CHI Introduction and Hands-On Demonstration.

The second day of the study began with a 2-hour classroom session that was used to familiarize the controllers with the DSR CHI. Representatives from the FAA Office of Air Traffic Systems Development (AUA) conducted the training. Graphic visual aids and other briefing materials were used to acquaint the controllers with the physical layout of the DSR workstation, and to describe keyboard inputs and displays. The intent of the effort was to provide the participants with knowledge of the display and input conventions used in DSR. Emphasis was placed on the differences between the PVD and DSR controller interaction requirements.

The CPDLC-I CHI elements were not addressed during this training session. However, in order to maximize the effectiveness of the classroom activity, topics that are closely associated with the CPDLC-I CHI were emphasized. These included the radar computer readout device (R-CRD), the keyboard category keys, the R-CRD category selection area, and the function keys.

Training was followed by a 2-hour interactive practice session in the DSR laboratory. The DSR consoles were configured to define contiguous airspace sectors. Simplified ATC scenarios developed for DSR testing and demonstration presented traffic flows passing through the three sectors. Controllers were assigned to the radar and data positions at each of the sectors and rotated positions to permit all participants to work with the system.

Predefined flight plans were used in the scenarios and no communications with the simulated aircraft were implemented. However, the controllers were able to make all DSR inputs and observe the results in the FDB displays and views.

The controllers were given a checklist of DSR tasks to perform while controlling traffic in the scenario. These tasks focused on the elements of the DSR CHI that will be used to incorporate CPDLC-I functionality. In particular, the tasks required the controllers to: (1) examine the content and manipulation of displays that will be employed by CPDLC-I or are similar to those that will be developed for CPDLC-I; (2) observe the current DSR keyboard assignments of the function and category keys; and (3) perform the actions that are required to offer and accept hand-offs. Facilitators were available to assist the controllers with the DSR inputs and acquaint them with the airspace and traffic flow in the simulated sectors.

3.3.3   Introduction to the CPDLC-I CHI for DSR.

After receiving training on the DSR display and input conventions and completing practice in using the CHI, the controllers were introduced to the proposed implementation of CPDLC-I on the DSR. A 1-hour classroom training session was conducted to present the proposed DSR keyboard inputs and displays associated with sending TOC, PDM and ASM, monitoring Data Link transactions including IC errors, and adjusting Data Link settings. In addition, the presentation covered the available category and function key assignment options for the Data Link and Data Link Settings keys that are used in composing a majority of the CPDLC-I inputs.

3.3.4   CPDLC-I Design Review.

The final activity of the second day of the study was a detailed evaluation of the CPDLC-I design. Each controller performed an independent evaluation by completing the questionnaire items contained in a design review booklet (see appendix B). The booklet structured the controller evaluations around five primary topics: (1) Data Link and Data Link Settings Category Key assignments, (2) Data Link FDB and Status List Displays, (3) TOC inputs and displays, (4) IC displays, (5) PDM inputs and

displays, and (6) ASM inputs and displays. The controllers were asked to rank their preferences for each of the available Data Link Category Key design options and to indicate any of the options that would be completely unacceptable.

The TOC, PDM, and ASM inputs and the TOC, PDM, and IC displays for DSR were presented for individual evaluation using descriptive text. In each case, the controller was asked to provide an overall evaluation of each service design and to record any recommended or required CPDLC-I design modifications resulting from a conflict between the proposed CPDLC-I design and DSR design conventions. They also were asked to indicate whether each of several potential enhancements to the CPDLC-I designs would be desirable for future builds of the system.

In order to facilitate the evaluations, the design review exercise was conducted in the DSR laboratory while the controllers were seated at the display consoles. This location permitted the controllers to refer to the DSR keyboard layout and to manipulate the display as needed to assist them in completing their evaluation booklets.

3.3.5 Structured Debriefing.

The final day of the study was devoted to a structured group discussion and debriefing session. The session was used to perform an item-by-item review of the controller's responses to the design review questions and ratings. The emphasis of the debriefing was to identify and resolve any disagreements regarding the suitability and acceptability of the proposed CPDLC-I functionality and CHI design, and to achieve consensus regarding options for the Data Link Category Key assignments. The group discussion was documented in notes recorded by test personnel and on an audiotape record for reference during data analysis and report preparation.

4. RESULTS.

The following findings are a synthesis of the inputs that were obtained from the independently written controller design reviews and the structured group debriefing.

4.1 DSR CATEGORY KEY REQUIREMENTS FOR CPDLC-I.

The design of the DSR/Host Computer System software architecture permits the entry of commands at the Radar position by a two-step process. Pressing one of the keyboard Category Keys (or trackball selecting a key in the R-CRD Category selection area) gives the controller access to a group of functions subsumed under that category. These

functions are displayed in the R-CRD view that can then be selected by trackball or by pressing one of the keyboard Function keys. The first function in the group is assigned default status, and need not be pressed/selected to complete the command sequence.

The proposed design that was presented to the controllers for review called for two category keys to be assigned to CPDLC-I. One of these was labeled the Data Link category (DL) and would be used to compose and send messages. The Data Link Settings category (DS) would be used to set the TOC mode, the ASM mode, display a list of current sector Data Link settings, and to select or modify the contents of Data Link lists. During the individual design review, each controller was asked to indicate his preference for rearranging the assignments of the six category keys to accommodate these two CPDLC-I categories.

The subsequent structured debriefing resulted in a clear majority of the participants adopting a proposal that was originally offered by five of the controllers in their individual comments. The group indicated that a total of three category keys would be required to implement CPDLC-I in a form that will be acceptable to controllers. Two of the keys are needed to provide single keystroke access to the primary CPDLC-I TOC and PDM services. These keys must be represented in the keyboard Category Key Area and in the R-CRD category selection area. The third key is needed to provide access to the Data Link Settings function and can be implemented on the R-CRD and as a secondary function of one of the keyboard category keys accessed by depressing the "Multifunction" keyboard key.

This requirement was driven by the nature of the Host controller interface and software architecture. As discussed above, according to the design conventions of this architecture only one group of functions can be accessed by a category key. Of the group, one of the functions is a default choice (hot key). Consequently, only the default function can be accessed by a single keystroke. The controllers indicated that the functions of transmitting a "held" TOC message and selecting a PDM menu item must both be available with a single input action. As a result, two independent keys will be required for these services.

The controllers stated that failure to provide this level of access to one of the services would seriously compromise its utility and would almost certainly result in a low level of usage in the field.

Several options were considered for positioning these keys in the six-key Category Key area. Based on the individual responses obtained from the design review booklets, the preferred keys for use in accessing the TOC category and the (PDM) category included any of the keys in the top row

of the area and the first key on the left of the bottom row. Existing function categories that the controllers indicated could be effectively combined to free two of the keys were EMER CHK / POS CHK and RSB / RNG BRG. In DSR, the subordinate function is selected on a combined key by pressing the MULTI FUNC keyboard key prior to pressing the category key.

While no final consensus on a specific keyboard layout was achieved, the following arrangement was suggested as a preliminary alternative:

Keyboard Category Keys

DL TOC / DS	METER LIST	SIM
DL MENU	RNG BRG RSB	POS CHK

R-CRD Category Selection Area

DL TOC	METER LIST	SIM	EMERG CHK	
DL MENU	RNG BRG RSB	POS CHK	DS	

On the keyboard, the key labeled DL TOC would access all TOC options and would have "Uplink held TOC" as the default function. The secondary function on the keyboard DL TOC key would be DS (data link settings) which would be accessed by depressing the multifunction key prior to selecting the key. The DL Menu key would access all PDM options.

When using the R-CRD Category Selection area, the DL TOC and DS functions would be provided by separate keys since no multifunction capability is available when using trackball selection in DSR. RNG BRG and RSB could be combined on the R-CRD and keyboard because the total number of functions for these categories does not exceed the maximum of 10 for any category.

If two keyboard keys cannot be provided in DSR for CPDLC-I, the only remaining alternative would be to violate the Host architecture design

conventions in order to permit the use of a single Data Link key while preserving single keystroke access to all important message types.

4.2 ADAPTABLE INITIAL CONTACT DATABASE ALTITUDES.

The requirements for CPDLC-I IC were designed to be compliant with FAA Directive 7110.65 *Air Traffic Control.* This directive stipulates that the aircraft data block must reflect the aircraft's assigned altitude. Based on this guidance, the automated check of an aircraft's reported altitude for the IC service was designed to make a comparison between the most recent assigned or interim altitude entered into the system and the pilot's downlinked report.

One of the strongest recommendations of the group concerned this aspect of the CPDLC-I IC service design. In the individual design reviews, nine of the participants noted that this message will not be acceptable unless the software used to check the pilot's downlinked reported altitude is modified to permit the use of an alternative altitude as well as the assigned or interim altitude currently stored in the NAS database.

This recommendation was driven by an Order modifying 7110.65 that is in force at many ARTCCs (including Minneapolis) which states that an interim altitude entry is not required when a climbing aircraft is assigned an altitude strictly based on sector stratification and is expected to be recleared to a higher altitude immediately upon hand-off acceptance by the controller of the receiving sector in the next higher altitude strata. This procedural modification is based on paragraph 5-192b of the 7110.65 which stipulates that the requirement to enter an interim altitude when an aircraft is assigned an new altitude for a short period of time, and will be subsequently recleared to a new altitude, may be deleted where "heavy traffic or sector complexity precludes such action and compliance is not practicable."

During the debriefing session the group argued that failure to permit the use of alternative altitudes for aircraft whose flight data meet specific criteria would result in a high rate of false incorrect altitude report alerts. This outcome would lead to decreased detectability of true altitude mismatch alerts and increased controller workload involved with deleting the alert. It was noted that failure to resolve this design deficiency would be likely to result in Minneapolis controllers abandoning the use of the IC service during the CPDLC-I field implementation.

4.3 "NO RESPONSE REQUIRED" MESSAGE TYPE OPTION FOR PREDEFINED MESSAGES (PDM).

The CPDLC architecture requires that all messages be assigned to one of four categories defined by the types of pilot response that will be accepted by the system. In CPDLC-I, only three of these are presently included. No provision is made for a message that requires no response from the flight deck.

The controllers argued that this omission will limit the utility of PDM because most noncritical messages that can be sent in CPDLC-I will be informational, and many of these will be sent using the "ALL" command. Such messages do not require responses. The consequences of failing to provide a "no response" option would be added aircrew workload, unnecessary clutter in the status list when the "ALL" command is used, and the potential for interference with ATC operations when open transactions unnecessarily prevent NAS sector hand offs.

4.4 FULL DATA BLOCK EQUIPAGE/ELIGIBILITY SYMBOLS.

The group concurred that the graphical symbols used as Data Link equipage/eligibility indicators in the FDB should be improved. The open diamond and hourglass symbols were holdovers from the PVD prototype, which has a restricted symbol set. Early ATDLVT development studies had shown that these symbols should be changed for future systems, and that open and closed diamonds would be preferred. Nine of the 11 participants who expressed an opinion concurred with this preference.

It was recommended that the diamond symbology be used for CPDLC-I operational effectiveness testing. However, because of possible confusion with the open diamond used as a position symbol, it was suggested that this issue be addressed during testing. If the results indicate that confusions are possible, other symbols available on the DSR should be examined as alternatives.

4.5 D CONTROLLER STATUS LIST AND CATEGORY KEYS.

The controllers agreed that, because the D controller is likely to be a user of CPDLC-I, Data Link inputs and displays for this position should be improved to enhance the speed and accuracy of controller performance. Specifically, the controllers indicated that a status list should appear on the D monitor along with the D-CRD. As a minimum, this list should be a repeater of the R status list, conforming to the message filter settings of the R list. A more flexible and desirable option would be a list that was independently filterable by the D controller.

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In addition, the group indicated that the D position should be provided with keyboard category keys that mirror those provided on the R keyboard. These keys would provide the D controller with the capability to gain one keystroke access to Data Link functions rather that using the more time consuming and memory intensive two-letter Host designators.

4.6   TRACKBALL INPUTS FOR PDM MESSAGE SELECTION.

The controllers indicated that both trackball and single keystroke methods of access would be required for important CPDLC-I functions to accommodate different controller styles of interacting with DSR. This argument was the basis for requiring two Category keys to provide single keystroke access to TOC and PDM.

In the reviewed design, TOC provides the controller with the alternative trackball selection of a status list item to uplink a held TOC message. However, no equivalent trackball alternative is provided for PDM. The group's recommendation was to include this capability for CPDLC-I by permitting the controller to trackball select a menu item from the menu text list as an alternative to pressing the Data Link menu key and entering the menu item referent.

4.7   TRANSFER OF COMMUNICATION.

The group made two recommendations for minor changes to Build I TOC commands. The commands used to override the active mode for a single transaction use the letter M to change to manual while in automatic mode and the letter T to change to automatic while in manual mode. The controllers agreed that M should be changed to I (Inhibit) and T to S (Send).

The primary reason for this change was a perceived improvement in the intuitiveness of the commands and consistency with other uses of these abbreviations in CPDLC Build II where M will be used for Mach and T for temporary (altitude). In addition, Build II will reserve several other characters for Data Link inputs (A, T, H, K, M, I, S, R, Z). Avoiding the use of these in Build I, it was argued, will ease eventual transition at Minneapolis ARTCC and prevent possible inadvertent carry-over of the conflict during Build II development.

The controllers also noted that the letter O is used in the command to initiate a sector handoff without preparing or sending a TOC message. The controllers indicated that some other character should be used to prevent confusion with the number zero.

Other recommendations regarding TOC included making "OFF" the default TOC mode on startup for CPDLC-I rather than "MAN" or "AUTO" to prevent inadvertent preparation or sending of messages by a controller not using Data Link. In addition, it was noted that the automation should be adapted to enforce the CPDLC procedure forbidding simultaneous engagement of auto TOC and auto handoff.

Finally, the controllers agreed that a TOC mode indicator (OFF/AUTO/ MAN) should be continuously presented on the situation display to ensure mode awareness and prevent errors. This indicator was predicted to be especially useful during the position relief process.

4.8   OTHER FINDINGS.

Miscellaneous inputs and recommendations from the controllers regarding the CPDLC-I interface are presented in the following list:

    a. Error status messages (e.g., FAI, ERR, IIC) in the Status List should be highlighted to facilitate detection.

    b. Efforts should be taken to simplify supervisory inputs required to modify PDM menus. This task should minimize the time that the supervisor must spend away from the control area.

    c. Modifying Data Link Settings should not require the controller to memorize complex keyboard entries. Embedded menus that can be selected with the trackball would insure accurate performance when setting service modes and setting filters on the contents of the status list.

    d. In order to minimize display clutter, the status list should not be grouped with other lists (e.g., inbound, hold, departure) for the purposes of suppression, setting brightness levels etc.

5.   CONCLUSIONS AND RECOMMENDATIONS.

This design review exercise produced data on controller preferences for the assignment of display system replacement (DSR) Category keys to Controller-Pilot Data Link Communication Build 1 (CPDLC-I) functions. It also generated findings based on subject matter expert opinion which indicate that modifications are needed to the proposed CPDLC-I control, display, and service designs.

The following recommendations from the design review are grouped into two categories. The first category comprises design requirements and changes judged by the participants to be essential to the successful

deployment of CPDLC-I during the key site field implementation. A majority of the participants indicated that failure to implement this group of recommendations would prevent controllers from effectively using one or more of the CPDLC-I services.

The second category of recommendations consists of improvements that the participants felt would significantly improve the acceptability of CPDLC-I and the effectiveness and accuracy of controller performance.

5.1   ESSENTIAL REQUIREMENTS AND MODIFICATIONS.

a. To conform to DSR/Host command structure conventions and provide single keystroke access to primary messages, three Category Keys are required for CPDLC-I. Two of these keys must be assigned to transfer of communication (TOC) and predefined messages (PDM) function categories. The third should be assigned to Data Link Settings, and can be a secondary function on one of the Keyboard Category Keys and/or appear only in the R-CRD Category Selection Area.

b. The initial contact (IC) service design must be modified to permit the downlinked assigned altitude report to be compared to an adapted altitude as well as the assigned or interim altitudes contained in the National Airspace Systems (NAS) database.

c. The "no response required" message type must be added to the current set of response options.

5.2   MODIFICATIONS TO IMPROVE CONTROLLER ACCEPTANCE AND PERFORMANCE.

a. The Full Data Block (FDB) equipage/eligibility indicators should be changed. An open diamond should be used to indicate that the aircraft is currently capable for Data Link communications and the observing sector is not eligible. A filled diamond should be used to indicate that the observing sector is eligible to communicate with the aircraft via Data Link. The effectiveness of this symbology should be investigated in simulation testing prior to, or during CPDLC-I Operational Testing.

b. A Status List should be available on the D controller display.

c. Category Keys for CPDLC-I functions should be provided on the D Controller Keyboard.

d. The option should be provided to permit selection of a message from the PDM menu by trackball designation of the item as well as by the keyboard entry method.

e. The commands used to override the active TOC mode for a single transaction should be changed. The letter "I" (inhibit) should be entered in the command sequence to change to manual while in the automatic mode. The letter "S" (send) should be used to change to automatic while in the manual mode.

f. The letter entry O used in the command to initiate a sector hand off without preparing or sending a TOC message should be changed to another letter in order to avoid confusion with the number zero.

g. The default mode for TOC should be "OFF" rather than "AUTO" or "MANUAL".

h. The automation should be adapted to enforce the procedure forbidding simultaneous engagement of auto handoff and auto TOC.

i. A TOC active mode indicator (OFF, MAN, or AUTO) should be continuously present on the situation display.

j. Status indicators of errors in the Status List (e.g., ERR, FAI, IIC) should be highlighted.

k. Embedded menus should be used to select options when setting status list filters and selecting service modes.

l. The location of input devices for supervisory inputs to PDM and the user interface should be designed to minimize time away from the control area.

6.   ACRONYMS AND ABBREVIATIONS.

ARTCC	Air Route Traffic Control Center
ASM	Altimeter Setting Messages
ATC	Air Traffic Control
ATDLVT	Air Traffic Data Link Validation Team
ATN	Aeronautical Telecommunications Network
AUA	Air Traffic Systems Development
CHI	Computer-Human Interface
CPDLC	Controller-Pilot Data Link Communications
CPDLC-I	Controller-Pilot Data Link Communication Build I
DL	Data Link
DSR	Display System Replacement
DYSIM	Dynamic Simulation
EMER CHK	Emergency Check
FAA	Federal Aviation Administration
FDB	Full Data Block
IC	Initial Contact
ICAO	International Civil Aviation Organization
MULTI FUNC	Multi Function
NAS	National Airspace System
NATCA	National Air Traffic Control Association
OT	Operational Test
PDM	Predefined Messages
POS CHS	Position Check
PVD	Plan View Display
R-CRD	Radar Computer Readout Device
RNG BRG	Range Bearing
RSB	Radar Sort Box
TOC	Transfer of Communication
VHF	Very High Frequency

APPENDIX A

Individual's Consent to Voluntary Participation in a Research Project

FAA William J. Hughes Technical Center

Individual's Consent to Voluntary Participation in a Research Project

I _____, understand that this study entitled "User Involvement Study: Design Review of the Display System Replacement Computer-Human Interface for Controller-Pilot Data Link Communications – Build I" is sponsored by the Federal Aviation Administration and is being directed by the Data Link Branch (ACT-350) of the Communications, Surveillance and Navigation Division.

I have been recruited to volunteer as a participant in the project named above. The purpose of this project is to obtain expert controller input regarding the design of the inputs and displays that will be used to provide an initial Controller-Pilot Data link Communication Build 1 (CPDLC-I) capability on the Display System Replacement (DSR) controller workstation.

<u>Nature and Purpose.</u>

The project will involve my participation over a period of 3 days. There will be approximately nine other en route ATCSs participating with me. The project activities will take place during normal workdays with breaks for meals. I will be required to attend classroom training sessions and practice sessions in the ATC simulation laboratories to acquaint me with Data Link and the DSR. I will then perform an individual evaluation of the CPDLC-I computer-human interface (CHI), and participate in a group debriefing.

<u>Study Procedures.</u>

The study will begin with a classroom training session on the CPDLC CHI originally developed for the Host/PVD system. This will be followed by simulation exercises in the ATC simulation laboratory to familiarize me with the Data Link commands and displays as implemented on the PVD. Next, classroom training on the display and input conventions of the DSR will be provided along with hands-on simulation exercises on the DSR. Finally, a classroom session will be used to describe and illustrate the proposed CPDLC-I CHI for DSR.

I will use these experiences as a basis for completing an individual design review of the proposed CPDLC-I CHI for DSR. The design review booklet will provide a description of each design feature and provide space for my comments and recommendations. It will also allow me to express my preferences regarding certain unresolved design issues. The project will conclude with a structured group debriefing to identify individual areas of concern and to achieve consensus where possible.

Discomfort and Risks.

I understand that there are minimal physical or psychological risks associated with participation in this study. The Host/PVD simulation facilities use equipment and workstations that are identical to those currently used by en route controllers in ARTCCs. The DSR simulation laboratory uses preproduction models of the DSR workstation that will be installed in ARTCCs to replace the PVD. The tasks that I will perform in the laboratories will be the same, or similar, to those I perform in my job as an ATCS.

Precautions for Female Participants.

The risks of participating in this study are substantially the same as those encountered by operational en route ATCSs performing their normal duties. If I am a female ATCS, I understand that I must exercise the same precautions that I would at my job to avoid risks to myself, the embryo or fetus if I currently am, or may become pregnant.

Benefits.

I understand that the only direct benefit to me is that I will receive my normal FAA pay and travel reimbursement while participating in this study.

Participant Responsibilities.

I understand that by volunteering for this study that I accept the obligation to make an honest evaluation of the CPDLC-I CHI for DSR based on my past experience as an en route ATCS and on the information and simulation experiences that are provided to me during this study.

Compensation and Injury.

I agree to report any personal injury or suspected adverse effect of this study to Mr. Darby at 609-485-6345. I understand that, as an official government employee duty, accident insurance coverage for this study activity is provided by the Workmen's Compensation Insurance Fund in relation to my Federal Government employment.

<u>Participant's Assurances</u>.

I understand that my participation in this study is completely voluntary. I am participating because I want to. Mr. Darby has adequately answered any and all questions that I have about this study, my participation, and the procedures involved. I understand that Mr. Darby will be available to answer questions concerning procedures throughout this study.

I have not given up any of my legal rights or released any individual or institution from liability for negligence.

I understand that records of this study will be kept confidential, and that I will not be identifiable by name or description in reports or publications about this study.

I understand that I may withdraw from this study at any time without penalty or loss of benefits to which I am otherwise entitled.

If I have questions about this study or need to report adverse effects from the study activities, I will contact Mr. Darby at 609-485-6345 during the workday or 1-800-832-2506 at all other times.

I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I have received a copy of this consent form.

Study Participant: _____ Date: _____

Investigator: _____ Date: _____

Witness: _____ Date: _____

APPENDIX B

Controller Design Review Booklet

CPDLC-I

CONTROLLER DESIGN REVIEW BOOKLET

This booklet contains a series of questions that will permit you to independently review the CPDLC-I services that will be implemented on the DSR. The goals of this review are to (1) resolve some open design issues, and (2) obtain your inputs and recommendations regarding the service designs.

Please answer all of the questions in this booklet and carefully record your comments and any recommendations. Please explain your reasons for suggesting any changes.

Your primary task during this exercise is to concentrate on completing the review booklet. We are doing the review in the DSR laboratory in order to give you the opportunity to examine the DSR displays and keyboard layout in the course of making your evaluations.

Reviewer's Name _____

PART I

Data Link Key Options

The CPDLC-I CHI for DSR requires a capability for controllers to select two unique groups of Data Link functions. The Data Link function (DL) is used to compose and send messages. The Data Link Settings function (DS) is used to set the Transfer of Communications mode, the Altimeter Setting mode, display a list of current sector Data Link settings, and to select or modify the contents of Data Link lists.

To select these function groups from the D position, the controller will be required to enter two-character Host-type designators on the alphanumeric keyboard. At the R position, category keys located on the keyboard or in the R-CRD view may be used as the DL and DS keys. Selecting one of the keys will display a menu in the R-CRD text area referring to the soft function keys that must be depressed (or selected by trackball in the R-CRD category selection area) to complete the command. One of the functions displayed in the text area will be highlighted, designating it as the "hot" function. The "hot" function need not be selected when completing the associated command sequence.

Instructions

The following list presents three overall category key assignment options for the DL and DS functions at the R position. In evaluating these options you should consider how often controllers will use the Data Link functions as well as other functions selected from the Category Keys and R-CRD Category Selection Area. You also should consider the ease and accuracy with which controllers will be able to locate and activate functions positioned in various places on the DSR keyboard.

<u>Please rank the options from 1 "most acceptable" to 3 "least acceptable". If you feel that an option would be completely unacceptable to controllers, do not assign a rank to that option and write the letter "U" in the blank.</u>

After ranking the overall options that would be acceptable, select the specific implementation of the options that you feel would be preferable to controllers.

_____ Option A: Redefine Two Keyboard Category Keys
Rank
Redefine two of the keyboard Category Keys as DL and DS. The original functions of the redefined keys would remain available in the R-CRD Category Selection Area.

Select two Category Keys that would be most acceptable for redefinition under this option from the following:

        POS CHK
        EMERG CHK
        SIM
        MET LIST

DL key choice: _____

DS key choice: _____

_____ Option B: Redefine One Keyboard Category Key
Rank
Redefine one of the keyboard Category Keys as the DL key and make the DS key function available only in the Category Selection Area of the R-CRD. The original function of the redefined keyboard Category Key would remain available in the R-CRD Category Selection Area.

Select one keyboard Category Key that would be most acceptable for redefinition as the DL key under this option:

        POS CHK
        EMERG CHK
        SIM
        MET LIST

DL key choice: _____

_____ Option C: Combine Two Category Key Functions
Rank

Combine two of the existing keyboard Category Key functions onto one key, and use the free Category Key as the DL key. Make the DS key function available only in the Category Selection Area of the R-CRD.

The following combinations would be allowable in DSR. Select one that would be most acceptable under this option:

_____ RSB and RNG BRG in RSB position (DL in RNG BRG position)

_____ RSB and RNG BRG in RNG BRG position (DL in RSB position)

Comments:

Instructions for Parts II - VI

The next five parts of this booklet will permit you to perform a detailed review of the CPDLC-I controller interface design. Each part begins with a design description. Read these descriptions carefully before recording your comments.

NOTES ON CONVENTIONS USED IN THE DESIGN DESCRIPTIONS

- Data <u>as shown in a display or entered on the keyboard</u> are presented in quotation marks. When spaces are required, they are included within the quotation marks. The quotation marks are not part of the display or entry.

- All spaces included within quotation marks for keyboard entries are mandatory. For example, "MT ON" should be interpreted as typing MT, a space, and ON.

- Input commands printed in bold italics refer to a DSR keyboard category, soft function, or function (QAK) key, or a "key" in the R-CRD Category Selection Area (e.g., *DL, DS, FI*).

- Two trackball keys are used. Trackball ENTER (middle key) is used to complete a command sequence. Trackball SELECT (left key) is used to identify an item in the R-CRD text area or the Status List and to identify lists for moving them on the display.

- FLID refers to any NAS command for identifying a flight including:

   . The Aircraft Identification Call Sign (AID)

   . The Computer Identification Number (CID)

   . The Beacon Code

   . Positioning the trackball cursor over the data block and   pressing trackball ENTER

- All keyboard entries must be followed by a keyboard ENTER or a trackball ENTER to complete the command sequence.

Part II

Status List and Full Data Block

- Function

The Full Data Block (FDB) provides unique graphic characters which indicate that an aircraft is equipped to receive Data Link messages, and whether the observing control position is eligible to uplink messages to the aircraft. The FDB also provides limited information about the status of ongoing Data Link transaction.

The Status List is a Host situation display tabular list that contains full information about the content and current status of ongoing Data Link transactions. The Status List does not appear on the D position display.

- Full Data Block Equipage and Eligibility Indicators

Data Link equipage and eligibility are indicated by graphic characters located in the first position of the first line of the FDB. No special character in this position identifies an aircraft that is not capable of communicating via Data Link. An "open diamond" (◊) indicates that the aircraft is Data Link equipped, but that the viewing sector position is ineligible to communicate with it. An "hour glass" (⧖) indicates that the aircraft is equipped and that the viewing sector is eligible.

- Status List Format

The Status List is identified by "SL" displayed in the upper left corner of the list. Each line of the list contains information about one ongoing transaction. A line has three data fields displaying (1) the aircraft identification, (2) an abbreviated version of the content of the uplinked message, and (3) and an indication of the current status of the transaction. For example, "UAL172 123.125 SNT" would indicate that the controller had uplinked a message to UAL 172 to switch radio frequencies to 123.125 and that the message is in the sent status.

- Status List Abbreviations of Transaction Status

The third field of a status line presents the following abbreviations to indicate the current status of the transaction:

"SNT" - Sent: A controller input or system event has initiated the uplink.

"HLD"   - Held: A transfer of communication message containing the radio
            frequency of a new airspace sector, which the aircraft will enter, has
            been prepared and is ready for uplink when the sending controller
            makes an appropriate input.

"ROG"   - Roger
"AFF"   - Affirmative
"WIL"   - Wilco: The system has received a downlink from the flight deck
            indicating that the pilot has received the message / agrees with / or
            will comply with the uplinked message.

"NEG"   - Negative
"UNB"   - Unable: The system has received a downlink from the flight deck
            indicating that the pilot has received the the uplinked message, but
            does not agree with / is unable to comply.

"TIM"   - Time Out: A timer initiated when the uplinked message was sent
            has expired. This is an adaptable time parameter nominally set at 40
            seconds. The time out status is an indication to the controller of an
            unusually lengthy delay for receipt of a response from the aircraft.
            The transaction remains open, and a subsequent response will be
            accepted by the system.

"FAI"   - Failed: The system failed to successfully deliver the message to
            the service provider

"ERR"   - Error: Indicates that the service provider was unable to deliver the
            message to the aircraft within the maximum allowable time.

All states that close a transaction with a positive response (ROG, WIL, AFF) will
delete the relevant line on the Status List after an adjustable time parameter
(nominally 6 seconds) has expired. Messages in any other transaction state
must be manually deleted using inputs described in succeeding sections of this
booklet.

- Full Data Block Indications for CPDLC-I Services and Status

FDB indicators are correlated with the Status List indicators, but vary depending
upon the service involved. They are described in detail under succeeding
sections devoted to each service.

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- Inputs to Move the Status List

The Status List can be moved to any position on the situation display by using the trackball to SELECT the header area of the list and pressing the trackball ENTER to indicate the list's new position.

- Inputs to Suppress or Retrieve the Status List

The Status List can be suppressed by typing *DS F9* "OFF". The list is retrieved to the situation display by typing *DS F9* "ON". These entries cannot be made from the D position.

- Selecting Message Types for Display in the Status List

The Status List will display information on all four types of message included in CPDLC-I. However, the controller can selectively suppress Status List content by message category. The following table presents the commands used to selectively suppress and retrieve each message type.

	R Position Only	R and D Position
Transfer of Communication	*DS F8* "TC OFF" or *DS F8* "TC ON"	"SV TC OFF" or "SV TC ON"
Menu Text	DS F8 "MT OFF" or *DS F8* "MT ON"	"SV MT OFF" or "SV MT ON"
Initial Contact	*DS F8* "IC OFF" or *DS F8* "IC ON"	"SV IC OFF" or "SV IC ON"
Altimeter Setting	*DS F8* "AS OFF" or *DS F8* "AS ON"	"SV AS OFF" or "SV AS ON"
All Message Types	*DS F8* "OFF" or *DS F8* "ON"	"SV OFF" or "SV ON"

It is also possible to display or suppress multiple message types in a single command (e.g., *DS F8* "TC MT OFF").

- Selecting Message States for Display in the Status List

The controller also can determine the messages that will appear in the Status List by their respective states. The following table presents the commands used to selectively suppress and retrieve the display of messages in four states. Messages with any other status cannot be suppressed.

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	R Position Only	R and D Position
SENT	*DS F10* "SNT OFF" or *DS F10* "SNT ON"	"SZ SNT OFF" or "SZ SNT ON"
ROGER	*DS F10* "ROG OFF" or *DS F10* "ROG ON"	"SZ ROG OFF" or "SZ ROG ON"
WILCO	*DS F10* "WIL OFF" or *DS F10* "WIL ON"	"SZ WIL OFF" or "SZ WIL ON"
AFFIRMATIVE	*DS F10* "AFF OFF" or *DS F10* "AFF ON"	"SZ AFF OFF" or "SZ AFF ON"

Full Data Block and Status List Evaluation

Please record your comments and recommendations here.

Part III

Transfer of Communication (TOC)

- Function

The Data Link transfer of communication message is automatically prepared
when the receiving controller accepts a handoff for an equipped aircraft. The
sending controller has the option to send the new frequency automatically when
the handoff is accepted, or to send the message manually at a later time.

- Inputs to Set the Transfer of Communication Mode

Transfer of communication can be set to the automatic mode by typing *DS F1*
"AUTO" (R position) or "AT AUTO" (D position). The manual mode is selected
by typing *DS F1* "MAN" (R position) or "AT MAN" (D position).

Data Link transfer of communication capability can be turned off for the sector
by typing *DS F1* "OFF" (R position) or "AT OFF" (D position).

- Manual and Automatic Send Inputs

When in the automatic mode, the transfer of communication message will be
uplinked with no additional action by the sending controller when the receiving
sector accepts the handoff.

When in the manual mode, acceptance of the handoff will store the message for
later transmission. The message will appear in the Status List in the "HLD"
status. The controller can send the message by a trackball slew/ENTER to the
"dot" preceding the appropriate line in the Status List or by typing *DL F1* (R
position only) or "UH" followed by the FLID. (Note that the *F1* key entry may be
omitted because it is the "hot" key)

When using keyboard entries for the transfer of communication, frequencies
other than the primary default frequency can be substituted. Typing "U"
followed by a space before the FLID will substitute a predefined alternate
frequency. Typing a numeric radio frequency value in the same position will
send that frequency if adapted for the facility.

- Status List and Full Data Block Displays on Transfer of
   Communication

The Status List entry for a transfer of communication transaction presents the
AID, the uplinked frequency, and the current transaction status message. When
in a manual mode, the "HLD" status message is displayed until the controller
completes the slew action or keyboard entries to send the message. In the
automatic mode, the status line appears in the "SNT" state immediately after
acceptance of the handoff.

In either mode of operation, when the transfer of communication message is
sent, a "pound" symbol (#) replaces the Data Link equipage/eligibility indicator
in the first position of the first line of the Full Data Block. This symbol will
appear at all sectors displaying the aircraft's Full Data Block. When the wilco is
received from the flight deck, the pound symbol is replaced by the hourglass in
the receiving sector and by the open diamond in all other sectors.

In an interfacility transfer of communication, the receiving sector will display the
hourglass and all Data Link eligibility symbology will be removed from sectors in
the sending facility.

- Unable and Time Out Displays for Transfer of Communication
   and Controller Responses.

If the flight deck responds to a transfer of communication message with an
unable, "UNB" is displayed in the status field of the Status List. If the flight deck
fails to downlink a response within 40 seconds (adaptable) after the message was
sent, "TIM" is displayed in the status field.

The unable conditions also will cause the pound symbol in the first position of the
first line of the sending controller's Full Data Block to revert to the hourglass
symbol indicating that Data Link eligibility remains at the sending sector. All
other sectors will display the open diamond.

- Deleting Transfer of Communication Transactions

The controller can close the transaction and delete "UNB", "ERR", or "FAI"
indicators by typing *DL F3* "TC " and the FLID (R position only) or "DE TC" and
the FLID. If the controller chooses to delete a transaction in the "SNT" or "TIM"
states "/OK" must be included in the command sequence prior to "TC" (e.g., *DL
F3* "/OK TC USA219"). The transaction can also be deleted by eliminating the
"TC" in the command and using the trackball to select the dot preceding the
appropriate line in the Status List.

- Sending an Automatic Transfer of Communication When in Manual
  Mode

While working in the manual mode, the controller can selectively choose to send
the message automatically to an individual aircraft by adding a single keystroke
to the normal sequence used to offer a handoff. The transfer of communication
message will be sent automatically upon handoff acceptance if the controller
offers the handoff by typing the two-digit receiving sector number, " T ", and the
FLID (e.g., "22 T USA435). Alternate frequency options may be included in the
command. Only one aircraft may be designated in the message. Adding the "T"
to a single handoff command will not affect other subsequent aircraft handoffs,
and the selected mode will remain manual.

- Holding a Transfer of Communication When in Automatic
  Mode

While working in the automatic mode, the controller can selectively choose to
hold the message for an individual aircraft by adding a single keystroke to the
normal sequence used to offer a handoff. The transfer of communication
message will be put into the held status upon handoff acceptance if the controller
offers the handoff by typing the two-digit receiving sector number, " M ", and the
FLID (e.g., "22 M USA435). Alternate frequency options may be included in the
command. Only one aircraft may be designated in the message. Adding the "M"
to a single handoff command will not affect other subsequent aircraft handoffs,
and the selected mode will remain automatic.

- Changing Data Link Eligibility Without a Handoff

If a controller has track control for an aircraft, Data Link eligibility can be
acquired from another sector in the absence of a completed handoff by typing *DL
F8* (R position only) or "SX" followed by the FLID. This action does not uplink
the acquiring sector's radio frequency to the aircraft.

Track control and Data Link eligibility can be acquired from another sector in the
absence of a handoff with a single input by typing "/OK D" and the FLID.

CPDLC-I does not permit the controller to "force" Data Link eligibility to another
sector.

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- Sending a Radio Frequency to an Aircraft Without a Handoff

A controller at the R position who has Data Link eligibility can send his/her sector's radio frequency to the aircraft by typing *DL F10* and the FLID.

Frequencies other than the primary default frequency for the sector can be substituted. Typing "UF" followed by a space before the FLID will substitute a predefined alternate frequency. Typing a numeric radio frequency value in the same position will send that frequency if adapted for the facility.

When a frequency is sent in this manner, the message will instruct the pilot to "monitor" the new frequency. If "C" is inserted in the message after *F10* or UF, the message will instruct the pilot to "contact" the controller on the new frequency (e.g., "UF C NWA899).

- Initiating a Handoff without Preparing a Transfer of Communication Message

An aircraft that is Data Link eligible can be handed off without preparing or sending a transfer of communication message by typing the receiving sector's number, "O" and the FLID (e.g., "22 O USA219").

Transfer of Communication Evaluation

Please record your comments and recommendations here.

Part IV

Initial Contact (IC)

- Function

This service substitutes the initial radio call from the flight deck after a transfer of communication with a downlink report of assigned altitude. Under normal conditions, the initial contact procedure is automatic and transparent, and requires no controller interaction.

- Initial Contact Procedure

An altitude request message is automatically appended to the radio frequency assignment message that is uplinked during transfer of communication. The flight deck responds to the transfer of communication uplink by downlinking a wilco along with a report of assigned altitude to the receiving controller.

Receipt of the wilco response transfers Data Link eligibility to the receiving sector. In addition, the reported assigned altitude is automatically checked against the aircraft's assigned altitude (or interim altitude) recorded in the NAS database. If the aircraft's reported downlinked assigned altitude matches the database value, nothing is displayed at the sending or receiving sectors, and no additional controller action is required.

Note that the transfer of communication message will normally instruct the pilot to "monitor" the new frequency. If the receiving sector is not using the Initial Contact Data Link service, it will instruct the pilot to "contact" the controller at the new frequency and no altitude request will be sent.

- Discrepancy Between Reported and Assigned Altitudes

If the reported assigned altitude fails to match the assigned or interim altitude contained in the NAS database, the downlinked value followed by "I" will appear in the first four positions of the second line of the Full Data Block. This will timeshare every 1.5 seconds with the database value followed by the altitude conformance indicator. If the Mode C altitude had been displayed in this field when the timesharing began, the Mode C altitude would be shifted to the right of the second line to make it continuously viewable.

In addition to the Full Data Block display, a Status List entry will be created displaying the AID, the NAS data base altitude, and the downlinked altitude. The downlinked altitude will be right justified in the data field of the Status List. The status field will show "IIC" (e.g., TWA515 240 340/IIC").

The Data Link eligible receiving controller with track control may respond by contacting the flight deck via voice radio. The error displays may be cleared by entering the FLID, deleting the IC Status List entry (*DL F3* "IC" and the FLID (R position only) or "DE IC" and the FLID, or by updating the aircraft's assigned or interim altitude.

Initial Contact Evaluation

Please record your comments and recommendations here.

Part V

Predefined Controller Messages (PDM)
(Menu Text)

- Function

The PDM or Menu Text function permits the controller to uplink nonsafety
critical messages by selecting them from a predefined menu list. Menus can be
tailored to meet the specific requirements of individual airspace sectors.

- Menu Format

The menu is a Host situation display tabular list identified by "ML" in the upper
left corner of the list. Each line of the menu contains one message preceded by
an identifying menu referent used to select the message. The menu referent
must begin with an alphabetic character. Up to ten messages can be displayed in
the menu list. A sample menu is shown below:

A	WRI ILS OUT RWY 6 / 24
B	BAD WEATHER WARN
MIC	CHECK STUCK MIC
CALL	CALL COMPANY

- Inputs to Send a Menu Text Message

To send a menu text message, type *DL F9* (or "UM"), the menu item referent,
and the FLID (e.g. *DL F9* "A USA456"). Messages cannot be sent using a
trackball designation of the item in the menu text list.

The message can be sent to all aircraft that are Data Link eligible for the sector
by substituting " *ALL " for the FLID.

- Full Data Block and Status List Displays on Menu Text Uplink

When a menu text message is uplinked, an up-arrow (↑) symbol replaces the
hourglass in the first position of the first line of the Full Data Block at all
positions displaying the Full Data Block. The up-arrow is removed when the
system receives the appropriate positive or negative response from the flight
deck, when it is deleted from the Status List, or if an FAI or ERR indication is
returned.

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For all messages sent from the menu, the Status List will display the AID followed by the menu item identifier, and the current status of the transaction (e.g., "AA231 CALL SNT"). The Status List line is deleted when the appropriate positive response from the flight deck is received, or when it is deleted from the Status List.

When a message is sent to all aircraft, a single line is created in the Status List with "ALL" appearing the FLID field. The status line is deleted when all of the aircraft respond with the appropriate positive response. A separate line is created in the Status List for each negative aircraft response to an all message, or if a transmission error occurs ("ERR", "FAI").

- Deleting Menu Text Transactions

The controller can close the transaction and delete "UNB","ERR", "FAI", or "NEG" indicators by typing *DL F3* "MT" and the FLID (R position) or "DE MT" and the FLID (D position). If the controller chooses to delete a transaction in the "SNT" or "TIM" states, "/OK" must be included in the command sequence prior to "TC" (e.g. *DL F3* " /OK MT USA219"). The transaction can also be deleted by eliminating the "MT" and FLID in the command and using the trackball to select the dot preceding the appropriate line in the Status List. If the trackball is not used for this command, all MT transactions for the aircraft that are not in the SNT or TIM state will be deleted from the Status list.

- Controlling Menu Text List Content

A menu build function will be used by supervisory personnel to create sector-tailored menus. However, the controller will have the capability to determine whether the menu list will be displayed, and to selectively display or suppress individual items.

The menu list can be suppressed by typing *DS F2* "OFF". The list is retrieved to the situation display by typing *DS F2* "ON". These entries cannot be made from the D position.

Suppression of the individual messages in the menu is accomplished by typing *DS F3*, the menu item referent, and "OFF" (R position only) or "MS", the menu referent, and "OFF". A message can be retrieved by substituting "ON" in the command sequence.

Up to five messages can be suppressed or retrieved in a single command by separating the menu referents with spaces.

- Inputs to Move the Menu

The menu text list can be moved to any position on the situation display by using the trackball to SELECT the header area of the list and pressing the trackball ENTER to indicate the list's new position.

Menu Text Evaluation

Please record your comments and recommendations here.

Part VI

Altimeter Setting (ASM)

- Function

This Data Link message uplinks an altimeter setting to the flight deck. Normally, the uplink will be accomplished automatically in accordance with procedures and directives. An altimeter setting can also be manually uplinked by the controller.

- Manual Uplink of Altimeter Setting

An altimeter setting can be manually uplinked by the R position by typing *QD* (QAK), the designator for the station providing the local altimeter setting, "S" and the FLID. The entry for the D position substitutes "QD" for the QAK entry.

- Full Data Block and Status List Displays for Altimeter Setting Messages

When an altimeter setting message is uplinked either automatically or manually, an up-arrow (↑)symbol replaces the hourglass in the first position of the first line of the Full Data Block at all positions displaying the Full Data Block. The up-arrow is removed when the system receives a "ROG" or "UNB", or is deleted from the Status List.

For all altimeter messages, the Status List will display the AID followed by the station designator and the altimeter setting, and the current status of the transaction (e.g., "AAL231 DCA 2997 SNT"). The Status List line is deleted when a "ROG" is received. Messages in any other transaction state must be manually deleted.

- Deleting Altimeter Setting Transactions

The controller can close the transaction and delete "UNB", "TIM", "FAI" or "ERR" indicators by typing *DL F3* "AS" and the FLID (R position) or "DE AS" and the FLID (D position). If the controller chooses to delete a transaction in the "SNT" or "TIM" states, "/OK" must be included in the command sequence prior to "IC" (e.g., *DL F3* "/OK AS USA219"). The transaction can also be deleted by eliminating the "AS" and FLID in the command and using the trackball to select the line in the Status List. If the trackball is not used for this command, all ASM transactions for the aircraft that are not in the SNT or TIM state will be deleted from the Status list.

Altimeter Setting Evaluation

Please record your comments and recommendations here.

GENERAL QUESTIONS

1. Do the Full Data Block symbols for Data Link equipage and eligibility (open diamond and "hourglass) appear to conflict with other symbols in DSR?

2. Do the transaction status abbreviations used in the Status List appear to conflict with other abbreviations in DSR?

3. Does the design provide an adequate capability to filter the contents of the Status List (i.e., by message type and status)?

4. In future builds, would inclusion of category keys on the keyboard and in the D-CRD be useful if a D position controller is involved in sending Data Link messages?

5. In future builds, would a "repeater" of the Status List at the DSR
   D position display be desirable?

6. In the current design, the active transfer of communication mode
   (AUTO/MANUAL) can be determined by pressing the *DS* key and
   checking the mode in the R-CRD. In future builds, would a transfer of
   communication mode indicator that is present continuously on the
   situation display be desirable?

7. In future builds, do you feel that it will be useful to take advantage of
   the DSR's color capability to emphasize important information and
   warnings (e.g., color coding of unable responses, failures and timeouts in
   the Status List)?

8. Earlier CPDLC studies indicated that controllers would prefer the
   the Full Data Block indicators for equipage and eligibility be
   changed from the open diamond and "hourglass" to an open diamond
   (equipped but not eligible) and a filled diamond (equipped and
   eligible). Do you agree with this recommendation?